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HAND DELIVERY

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, NW
Washington, DC 20554

Re: CC Docket No. 92-297
Ex Parte Presentation

Dear Mr. Caton:

Representatives of Texas Instruments, Inc., met yesterday afternoon with Messrs. Donald Gips and Gregory Rosston of the Commission's Office of Plans and Policy, and Mr. Thomas Tycz of the Commission's International Bureau, on matters related to the pending proceeding in CC Docket No. 92-297. Texas Instruments, Inc., was represented by Gene Robinson and Paul Misener. The enclosed materials formed the basis of the discussions.

An original and two copies of this letter and enclosures are submitted. A copy of this letter, without enclosures, is being sent simultaneously to Messrs. Gips, Rosston, and Tycz.

Respectfully submitted,

Paul E. Misener
Counsel for Texas Instruments, Inc.

cc Mr. Donald Gips (w/o enclosure)
Mr. Gregory Rosston (w/o enclosure)
Mr. Thomas Tycz (w/o enclosure)

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Texas Instruments Incorporated

TEXAS INSTRUMENTS

Post Office Box 650311
Dallas, Texas 75265
7839 Churchill Way
Dallas, Texas 75251

November 28, 1995

Mr. John Knudsen
Motorola Satellite Communications
2501 South Price Road
Chandler, Arizona 85248

Dear John,

The enclosed material, which includes previous analyses and new studies conducted by the various LMDS participants, continues to point out the feasibility of the LMDS CPE subscriber transceiver return links and the Iridium MSS/FSS feeder links to operate as co-primary and share the 29.1 to 29.25 GHz spectrum.

The statistical analysis and the direct beam analysis of 12 September 1995 (attachment B) is supported by the proposed rules (attachment C) and attachments D through K. The population density and gateway parameters show acceptable bit error rates for the Iridium gateway link. An examination of the Iridium satellite orbits (attachment E) shows that for the mid-CONUS gateway the minimum elevation angle at which the satellite is visible is 11.9 degrees (not 5 degrees) and provides 4 dB of system power control margin to allow the Iridium feeder link margin to be maintained without degradation to the link's bit error rate. The power spectral density is shown by attachment F to be only dependent on the maximum EIRP at the periphery of the cell and not on the LMDS coverage radius. Also, attachment G shows that the look-up angle for CPE's is less than 5 degrees for a 30 meter hub antenna height, the maximum proposed by any of the LMDS operators in attachment B. Also, the CPE look-up angle is less than 10 degrees for hub to CPE distances of 2 KM and greater with 300 meter differential antenna heights. The slant range between the feeder link gateway and the satellite and the differential signal levels (attachment H) shows an additional 1.73 dB increase in the gateway signal with satellite elevation angles of 11 degrees. This increase signal is more than adequate to offset the 0.2 dB or 0.4 dB produced by either 5 or 10 percent interference. In fact, it is sufficient to offset a 10 dB interference increase as shown in attachment I.

The equivalent CPE sidelobe energy is shown in attachment J to offset the Iridium power control signal reduction with more than a 10 dB margin, (-21.5 dB for CPE's versus -10 dB for the MSS/FSS feeder link). Thus, there is no short range (90 degree elevation, 780 KM) incompatibility between the LMDS return links and the gateway satellite. Main beam coupling at this minimum range only results in 0.2 dB signal degradation which is easily overcome with an accordingly small increase in gateway transmit power.

Attachment K is an analysis of CPE transceiver fit to the proposed rules 21.1020 and 21.1021 of the Third NPRM for 28 GHz. This analysis shows that at 7.5 degrees elevation the power spectral area density is 2 dB to 9 dB below the required limit proposed by the Third NPRM for LMDS hubs. At 90 degrees elevation the power spectral area density is 6 dB to 15 dB below the required limit. Thus, the CPEs are capable of sharing the 29.1 to 29.25 GHz spectrum the same as LMDS hubs.

In summary,

- Acceptable bit error rates are achievable while sharing.(Attachments B-D)
- Minimum elevation for the mid-CONUS gateway is 11.9 degrees resulting in a 4 dB system power control margin. (Attachment E)
- Power spectral density is not dependent on LMDS cell radius. (Attachment F)
- Look-up angle for CPEs are typically not greater than 5 degrees. (Attachment G)
- Maximum slant range to the satellite is less at the 11 degree elevation
  - -results in 1.73 dB increase in the gateway signal, which is more than adequate to offset the 0.2 dB or 0.4 dB produced by either 5 or 10 percent interference.
  - -sufficient margin exist to offset 10 dB interference increase. (Attachment H and I)
- CPE aggregate sidelobe power decreases 11.5 dB more than the satellite power control at short range, 90 degree elevation. (Attachment J)
- CPE transceivers can fit the Proposed rules, 21.1020 and 21.1021 of the Third NPRM suggested for LMDS hubs. (Attachment K)

Thus, the analyses presented demonstrate the feasibility of the Iridium MSS/FSS feeder links to co-share the 29.1 to 29.25 GHz with CPE return links using the proposed rules of attachment C or the proposed hub EIRP spectral area density rules, 21.1020 and 21.1021, of the Third NPRM.

Regards,
Gene Robinson

Gene Robinson
Senior Fellow, Texas Instruments

Attachments A-K
Distribution

ATTACHMENTS
28 November 1995

LMDS SUBSCRIBER AND IRIDIUM CO-PRIMARY SHARING OF THE 29.1-29.25 GHZ BAND

ATTACHMENTS
28 November 1995

LMDS SUBSCRIBER AND IRIDIUM CO-PRIMARY SHARING OF THE 29.1-29.25 GHZ BAND

A. INTRODUCTION
-Extensive analysis shows LMDS subscriber return links and Iridium MSS/FSS feeder links can share the 29.1-29.25 GHz band.

B. LOCAL MULTIPOINT DISTRIBUTION SERVICE CUSTOMER PREMISE EQUIPMENT TRANSMISSION AND IRIDIUM SATELLITE RECEIVER COMPATIBILITY ANALYSIS, SEPTEMBER 12, 1995.
-LMDS subscriber CPE parameters and Iridium feeder links are shown to yield acceptable C/I ratios using both the statistical analysis program that models the LMDS CPE deployment and the direct beam interaction analysis.

C. PROPOSED RULES FOR LMDS SUBSCRIBER TRANSCEIVERS IN THE 29.1-29.25 GHZ BAND.
-Proposed rules for maximum EIRP, (20 dBW/MHz, clear air with power control and 14 dBW/MHz without power control), and antenna mask allows for co-primary operation.

D. POPULATION DENSITY AND GATEWAY PARAMETERS BIT ERROR RATE ANALYSIS.
-Shows Motorola's N/I and C/I ratio levels along with acceptable bit error rates for the Iridium gateway link.

E. AN EXAMINATION OF IRIDIUM ORBITS AND GATEWAY ELEVATION ANGLE-IMPACT ON SYSTEM AVAILABILITY IN THE PRESENCE OF LMDS SUBSCRIBER TRANSMITTERS, NOVEMBER 17, 1995. Eric Barnhart, CellularVision.
-Minimum elevation angle for mid-CONUS (40 degrees North Latitude) is 11.9 degrees and produces 4 dB system power margin available to allow Motorola to maintain their desired satellite receiver operating point.

F. TOTAL POWER SPECTRAL DENSITY DEPENDENCY, OCTOBER 29, 1995. Doug Gray, Hewlett-Packard.
-Total power spectral density is dependent only on maximum EIRP at the cell periphery.

G. LOOK-UP ANGLE VERSUS HUB ANTENNA HEIGHT, OCTOBER 29, 1995. Doug Gray, Hewlett-Packard.
-Subscriber look-up angle is less than 10 degrees for ranges greater than 2 KM (300 meter hub antenna height) and less than 5 degrees for ranges greater than 100 meters, (30 meter hub antenna height).

H. SLANT RANGE TO SATELLITE AND SIGNAL LEVEL VERSUS ELEVATION ANGLE. Leland Langston, Texas Instruments.
-Elevation angle of 11 degrees, (Iridium CONUS elevation angle minimum), versus 5 degrees produces 1.73 dB increase in gateway signal level due to decreased range and space loss.

I. EFFECTS OF 5 PERCENT INTERFERENCE ALLOCATION. Bill Myers, Texas Instruments
-An interference of -210 dBW/Hz (5 percent interference budget) only represents 0.2 dB change of the system noise temperature, an interference of -207 dBW/Hz, (10 percent interference budget) results in 0.4 dB thermal noise increase. An interference of -200 dBW/Hz (10 dB increase) results in 1.7 dB power change which can be easily compensated by the system margin due to reduced range (11 degree minimum elevation angle) or by increasing the gateway power by 1.7 dB.

J. EFFECT OF SATELLITE POWER CONTROL AT MINIMUM RANGE. Bill Myers, Texas Instruments
-The aggregate sidelobe power from CPE return link transmissions will produce signal reductions much greater than the satellite link power control reductions. For main beam coupling at minimum range (90 degree elevation) a CPE operating at the maximum proposed rule power will result in only 0.2 dB degradation.

K. ANALYSIS OF CPE TRANSCEIVERS SHOWS FIT TO THE PROPOSED RULES 21.1020 AND 21.1021 PER THE THIRD NPRM FOR 28 GHZ, NOVEMBER 14, 1995. Doug Gray, Hewlett-Packard.
-At 7.5 degrees elevation, the aggregate of the LMDS CPEs power spectral area density (PSAD) is 2 dB to 9 dB below the required limit proposed for hubs.
-At 90 degrees elevation, the PSAD is 6 dB to 15 dB below the required limit.

INTRODUCTION

EXTENSIVE ANALYSES SHOW LMDS SUBSCRIBER RETURN LINKS AND IRIDIUM MSS/FSS FEEDER LINKS CAN SHARE THE 29.1-29.25 GHZ BAND.

The following attachments are the results of studies and analyses conducted by the LMDS proponents, CellularVision, Endgate Technology, Hewlett-Packard and Texas Instruments. The following is a summary of the conclusions reached by the LMDS proponents.

- Acceptable C/I ratios and bit error rates are achievable while sharing. (Attachments B-D)

- Minimum elevation for the mid-CONUS gateway is 11.9 degrees resulting in a 4 dB system power control margin. (Attachment E)

- Power spectral density is not dependent on LMDS cell radius. (Attachment F)

- Look-up angle for CPEs are typically not greater than 5 degrees. (Attachment G)

- Maximum slant range to the satellite is less at the 11 degree elevation angle,
  - -results in 1.73 dB increase in the gateway signal, which is more than adequate to offset the 0.2 dB or 0.4 dB produced by either 5 or 10 percent interference.
  - -sufficient margin exist to offset 10 dB interference increase.
  - (Attachments H and I)

- CPE aggregate sidelobe power decreases 11.5 dB more than the satellite power control at short range, 90 degree elevation. (Attachment J)

- CPE transceivers can fit the proposed rules of the Third NPRM suggested for LMDS hubs, 21.1020 and 21.1021. (Attachment K)

The analyses presented demonstrate the feasibility of the Iridium MSS/FSS feeder links to co-share the 29.1 to 29.25 GHz with CPE return links using the proposed rules of attachment C or the hub EIRP spectral area density rules, 21.1020 and 21.1021, of the Third NPRM. The proposed rules of attachment C is recommended due to the simplicity of only having to specify the maximum EIRP and antenna mask.

ATTACHMENT B

LOCAL MULTIPOINT DISTRIBUTION SERVICE
CUSTOMER PREMISE EQUIPMENT TRANSMISSION
AND
IRIDIUM SATELLITE RECEIVER
COMPATIBILITY
ANALYSIS

SEPTEMBER 12, 1995

INTRODUCTION

Local Multipoint Distribution Service proponents met September 6-7, 1995, to conduct analysis to determine the feasibility of the various LMDS customer premise equipment (CPE) to use the 29.1 to 29.25 GHz band as the return link frequency to the LMDS hubs and demonstrate compatibility with the Iridium satellite receiver operating in this band. The typical CPE parameters were determined for four proposed LMDS systems from CellularVision, Endgate Technology, Hewlett Packard and Texas Instruments. These systems all make use of narrow beam antennas (2.5 to 4 degree beamwidth), return link power control to adjust the transmit power for rain attenuation and/or range (0.1 km to 2.0-5 km) from the CPE to the system hub and low EIRP density at maximum range(-44.6 dBW to -52 dBW). These parameters were then used in a statistical analysis derived from the program generated by the FCC during the Negotiated Rule Making Committee for 28 GHz in 1994 and in a direct beam interaction analysis. These analyses are presented in the following sections of this report.

SUMMARY OF RESULTS

The results of the analysis using a statistical approach to CPE distribution and transmission shows that the Iridium receiver carrier to interference ratio (C/I) requirement of 20.9 dB can be met with positive margin. In addition the direct beam analysis shows that the power spectral density of -26 dBW/MHz-km^2 can be met by the various LMDS CPE return links. Thus, the LMDS CPEs are capable of using the 29.1 GHz to 29.25 GHz band for return links without harmful interference to the Iridium satellite receiver. Table one is a summary of the C/I ratios provided by each of the LMDS systems and Table two provides a summary of the power spectral density for dense and sparse populated LMDS systems.

Table One: C/I Ratio Analysis Summary

System	Total C/I	Main Beam C/I
CellularVision	36.7	37.1
Endgate Technology	27.6	28.1
Hewlett Packard	41.9	43.1
Texas Instruments	35.4	36.0

Table Two: Power Density Summary

System	200 X 400 km, dBW/MHz-km^2	2000 X 400 km, dBW/MHz-km^2
CellularVision	-42.65	-46.65
Endgate Technology	-26.2	-30.2
Hewlett Packard	-34.56	-38.56
Texas Instruments	-39.67	-43.67

STATISTICAL ANALYSIS

Overview

The aggregate power density from LMDS subscriber transmissions directed toward the Iridium satellite vehicle is calculated for four LMDS systems, Texas Instruments, Hewlett Packard, Endgate Technology and CellularVision. The aggregate power density is compared to the satellite feeder power density to provide a C/I ratio. The satellite C/I for each of 4 LMDS system ranges from 27.6 to 41.9 dB with a desired C/I of 20.9 dB.

System Parameters

The satellite parameters used as inputs to the analysis program are as follows.

SV altitude=780.0 Km.
SV half power beamwidth (HPBW) =5.0 degrees
SV elevation angle to the edge of the HPBW = 7.5 degrees
SV feeder EIRP density = -21.1 dBW/Hz
SV antenna pattern for Iridium

LMDS system parameters that were used for the four different LMDS systems in the analysis program are listed below.

Table Three: Typical LMDS System Parameters

Parameter	TI	HP	EG	CV
Transmitter Power per RF channel (dBW)	-17	-19.6	-13	-23
Modulation Type	QPSK	QPSK	4FSK	QPSK
Bandwidth of RF channel (MHz)	2.5	1.0	24	1.0
Antenna Gain (dBi)	34	35	39	31
EIRP density (dBW/Hz)	-47	-44.6	-47.8	-52
Minimum hub-CPE range (Km)	0.1	0.1	0.1	0.1
Maximum hub-CPE range (Km)	5	2	2.2	5
Tower height (meters)	30	15	20	30
Hub spacing in HPBW (Km)	17	17	17	17
Hub spacing out of HPBW (Km)	68	68	68	68
Maximum look angle for 50% blocking (Deg)	5	5	5	5

CPE Antenna pattern envelope is specific for each LMDS supplier
(Frequency reuse is included in the hub spacing density for a reuse factor of 4)

As noted above, LMDS system specific parameters are included. A common hub spacing is used for each LMDS system. This is equivalent to CPE spacing for simultaneous transmissions based on a frequency reuse factor of 4. Adjustments are made in the results for variations to these parameters for each LMDS system.

Analysis Results

Outputs resulting from the program are listed below. Adjustments are made for different frequency reuse and hub densities for each LMDS system. The number of simultaneous hub receiving frequencies is equivalent to the number of CPEs transmitting simultaneously.

Table Four: Statistical Analysis Results

Data Output and Adjustments	TI	HP	EG	CV
CPEs in SV HPBW (frequency reuse 4x)	896	896	896	896
CPEs outside the SV HPBW	3940	3940	3940	3940
C/I for CPEs within the SV HPBW (dB)	36.0	41.4	35.1	37.1
C/I for all CPEs as an aggregate (dB)	35.4	40.2	34.6	36.7
Frequency reuse adjustment (dB)	-	-	-7.0 (4/20)	-
Concentration factor (dB)		1.7 (6/4)		
Resulting Total Aggregate C/I (dB)	35.4	41.9	27.6	36.7

Adjustments for frequency reuse and concentration factors effect the number of CPEs transmitting in the calculation of density and therefore are converted to a dB value. The dB value is used to adjust the program results. HP plans on a circuit concentration of 6x which would reduce the number of hubs. Endgate plans a frequency reuse factor of 20 rather than a value of 4 that was used in calculations. It should be noted that the hub spacing derived from the population density is valid for the Endgate Technology deployment which is based primarily on business applications. The resultant C/I ratio is conservative since the hub densities should be based on business distributions instead of general population distributions.

With worst case population density, worst case subscriber density area, LMDS suitability factor of 100% and fully loaded busy hour circuits, this analysis indicates the lowest LMDS supplier aggregate C/I created by subscriber transmissions is within the required Iridium C/I limit.

DIRECT BEAM INTERACTION

The statistical analysis approach presented above provides a snapshot of the total interference into the Iridium satellite by typical LMDS CPEs for four different LMDS systems. It includes interference from CPE antenna side lobes and possibly interference from main beam interaction between the CPE antennas and the satellite. However it is a statistical model and as such does not provide an indication of what the interference could be under certain worst case conditions. Therefore an analysis was performed to provide an estimate of the worst-case interference caused by LMDS CPE main beam interaction with the main beam of the Iridium satellite.

Overview

The computer model was exercised over many different geometries with different initial conditions. Although the results indicate that the expected interference from LMDS CPEs into the Iridium satellites is low, concern has been expressed that the model may not provide information about the interference under certain worst-case geometries and CPE operations. Therefore a separate model was developed to analyze the interference into the Iridium satellite by CPE transmitters when the parameters are adjusted for worst-case conditions. This model does not provide any estimate of the probability of this result, but only establishes an upper bound on the interference based on the worst-case conditions for direct main beam interaction.

The first step is to define the worst case scenario. Although a "worst-case" could be defined for all CPE antennas coupling into the Iridium satellite, this would be completely unrealistic because of the CPE distributions. Therefore we should define the worst-case scenario as one which is realistic, although highly improbable. The worst-case scenario will be defined based on the design parameters of the different LMDS systems and the expected deployment scenario. The analysis will be performed for the various LMDS system implementations and for two satellite footprints. The worst-case earth-satellite geometry is assumed to be one which places the satellite antenna 2.5 degrees above the horizon. All CPE antennas are assumed to be pointed at the horizon. Therefore the Iridium satellite "sees" all CPE antennas pointed in the direction of the satellite. Although the CPE antenna-satellite distance varies over the satellite footprint, this distance is assumed to be equal to the distance between the Iridium gateway and the satellite in each case. The analysis calculates the total LMDS CPE power spectral area density in the satellite footprint for this worst-case scenario and shows a range of -30.2 to -46.65 dBW/MHz-km^2 for the large satellite footprint.

System Parameters

There may be numerous LMDS system implementations. Therefore the analysis was performed for four typical LMDS system implementations which represent a broad range of system parameters and distribution geometries. The analysis was also performed for different system operating parameters. The LMDS system parameters used in the analyses are shown in Table Five. The satellite parameters are shown in Table Six. The parameters are based on maximum capacity and assume the full 150 MHz return bandwidth is utilized. The satellite elevation angle and subscriber antenna elevation angles are adjusted to provide maximum interference on the horizon..

Table Five: Direct Beam LMDS System Parameters

System Parameter	(TI) Sys 1	(CV) Sys 2	(HP) Sys 3	(EG) Sys 4
1. Number of Subscriber Channels in 150 MHz BW	60	150	150	6
2. Number of Subscribers per Node in 150 MHz BW	5760	14400	3600	120
3. Subscriber Distribution	------------Uniform-------------			
4. Subscriber Duty Cycle, %	4	4	4	100
5. Subscriber Antenna Elevation Angle, degrees	2.5	2.5	2.5	2.5
6. Subscriber Antenna Gain, dB	34	31	35	39
7. Antenna 3 dB Beamwidth, degrees	2.5	4.0	3.0	2.5
8. Subscriber TX bandwidth, MHz	2.5	1.0	1.0	24
9. Subscriber TX Power, Clear Air, dBW	-17	-23	-19.6	-13
10. Hub Density (Actual No. Hubs/Maximum No. Hubs)				
a. In 200 km X 400 km footprint	0.25	0.25	0.25	0.25
b. In 2000 km X 400 km footprint	0.1	0.1	0.1	0.1
11. Cell (hub) spacing, km	5	5	2	2.2

Table Six: Direct Beam Satellite Parameters

1. Satellite Footprint	
a. Small	200 km X 400 km
b. Large	2000 km X 400 km
2. Allowed Power Spectral Density	- 26 dBW/MHz-km^2
3. Receiver Bandwidth	6.25 MHz
4. Satellite Elevation angle, degrees	2.5

In addition to these parameters, a number of assumptions about the system were used in the calculations. These assumptions are:

Percent of CPE signals having same polarization as satellite	50%
Percent of CPEs having clear LOS path to satellite	50%
Percent of CPEs simultaneously active	50%

Direct Beam Interaction Analysis Results

The system parameters for the four systems were used to analyze the expected interference level radiated from within the satellite footprint. Two footprints were used: 200 X 400 km and 2000 X 400 km. The total interference was calculated in terms of dBW/MHz-km^2. The analysis procedure and equations are described in the following paragraphs and summarized at the end.

The first step is to calculate the Effective Isotropic Radiated Power (EIRP) from any CPE. This is calculated as follows:

$$P_{EIRP} = P_{TX} + G_{TX\ ANT}$$

The EIRP Power Spectral Density is then calculated, based on the channel bandwidth for the particular system:

$$PSD_{EIRP} = P_{EIRP} - 10 \log (BW)$$

Since Adaptive Power Control is used at each CPE to normalize the received power at the node or hub antenna, the average power of the CPE transmitter can be used. The average power is taken to be the power averaged over all CPE transmitters associated with a hub. Since the CPEs are uniformly distributed in area about the hub, the average power is the power radiated by a CPE located on the boundary of a circle which equally divides the coverage area of a hub. This distance is 0.707 R, where R is the cell radius. (The area of the hub coverage is πR^2 and the area within the circle bounded by 0.707 R is $(0.707)^2 \pi R^2 = 0.5 \pi R^2$.) Hence the average CPE TX power is 3 dB less than the power at maximum range; hence the PSD is also 3 dB less:

$$\overline{PSD_{EIRP}} = PSD_{EIRP} - 3 \text{ dB}$$

The next step is to determine the average area associated with each subscriber which causes interference into the satellite so as to determine the PSD area density. The first step toward this objective is to determine the average number of subscribers associated with a hub which can be transmitting on the same frequency. This is simply the total number of subscribers supported by a hub divided by the number of unique frequency channels.

$$N = (\text{Total No. Subscribers/hub})/(\text{Number of frequency channels})$$

The average number of subscriber or CPE antennas which couple with the satellite antenna is simply the ratio of the CPE antenna beamwidth, θ, to 360 degrees multiplied by N:

$$n = N\theta/360$$

Now the average area associated with an interfering subscriber can be computed. It is the total area, A, served by a hub (with cell radius R), divided by n:

$$A = \pi R^2$$
$$A' = A/n = \pi R^2/n$$

Now the desired Power Spectral Area Density, ψ, can be calculated:

$$\psi = \overline{PSD_{EIRP}} - 10 \log(\pi R^2/n)$$

The units of ψ are dBW/MHz-km^2. This value assumes that all subscribers transmit with a 100% duty factor. This is the case for some systems (e.g., Endgate Technology). However others are able to serve the stated number of subscribers based on a duty factor. In those cases, the Power Spectral Area Density value must be adjusted for the duty factor:

$$\psi' = \psi + 10 \log(\text{duty factor})$$

This is the average value associated with a single hub. The next step is to adjust the value for the wide area covered by the satellite footprint. Since the value is per unit area, it is only necessary to adjust the value based on ratio of coverage. The following factors are applied:

P_1	Percent of CPE signals having same polarization as satellite	50%	- 3 dB
P_2	Percent of CPEs having clear LOS path to satellite	50%	- 3 dB
P_3	Percent of CPEs simultaneously active	50%	- 3 dB
P_4	Percent of Hub coverage		
	For 200 X 400 km footprint	25%	- 6 dB
	For 2000 X 400 km footprint	10%	-10 dB

$$\Psi = \psi' + P_1 + P_2 + P_3 + P_4$$

The final Power Spectral Area Density, Ψ , is the effective value for the LMDS CPEs located within a specific satellite footprint (either 200 X 400 km, or 2000 X 400 km). It represents the worst case (realistic) power spectral area density seen by a satellite located at an elevation angle of 2.5 degrees and "seeing" the CPEs located within a CPE antenna beamwidth. This does not include any CPE sidelobe radiation, but only the radiation from the CPE main beam.

The analysis was implemented using a spread sheet to perform the calculations. The results are tabulated in Table Seven.

Table Seven. Typical CPE/Iridium Satellite Direct Beam Interaction Analysis

	TI Sys 1	CV Sys 2	HP Sys 3	EG Sys 4
No Sub Ch in 150 MHz BW	60	150	150	6
No Sub/Node in 150 MHz BW	5760	14400	3600	120
Subscriber Duty Cycle	0.04	0.04	0.04	1
Sub Ant Gain, dB	34	31	35	39
Sub Ant Beam Width, Deg	2.5	4	3	2.5
Sub TX Bandwidth, MHz	2.5	1	1	24
Sub TX Power, dBW	-17	-23	-19.6	-13
Hub Spacing, km	5	5	2	2.2
Avg PSD/MHz	10.02	5.00	12.40	9.20
Psi, dBW/MHz-sq km	-10.69	-13.67	-5.58	-11.2
Psi with duty factor applied	-24.67	-27.65	-19.56	-11.2
PSAD, Small Footprint	-39.67	-42.65	-34.56	-26.2
PSAD, Large Footprint	-43.67	-46.65	-38.56	-30.2

The analysis was completed for the four types of systems and for two footprint areas. The results are summarized in Table Eight.

Table Eight: Typical LMDS CPE/Iridium Main Beam Interaction Analysis

System	Power Spectral Area Density, dBW/MHz-km^2 For 200 km X 400 km Area	Power Spectral Area Density, dBW/MHz-km^2 For 2000 km X 400 km Area
Texas Instruments (Sys 1)	-39.67	-43.67
CellularVision (Sys 2)	-42.65	-46.65
Hewlett Packard (Sys 3)	-34.56	-38.56
Endgate Technology (Sys 4)	-26.2	-30.2

The results indicate that the Power Spectral Area Densities are below the levels necessary to provide the required C/I ratios at the satellite for the large foot print case, even under the worst case scenario. Even when combined with the interference caused by CPE antenna sidelobes, the levels are well below the tolerable levels (-26 dBW/MHz-km^2) for the satellite. When the satellite is well above the horizon, the main beam coupling will be significantly reduced. Therefore it is concluded that LMDS CPEs will not cause sufficient interference into the satellite to degrade performance of the satellite even under worst case conditions. This is achieved without any system constraints other than antenna sidelobe control, EIRP control and PSD control.

CONCLUSIONS

The C/I ratio results using the statistical approach for CPE distribution and return link operation, and the direct beam interaction analysis shows that the Iridium satellite receiver is not affected by the CPE return link transmission. In addition, the direct beam interaction analysis yielded power spectral densities lower than the specified -26 dBW/MHz -km^2. Thus, one can conclude that LMDS systems designed for the terrestrial applications can co-exist with the Iridium system and not cause harmful interference to the Iridium satellite receivers when the 29.1 to 29.25 GHz spectrum is used as return links from the LMDS CPEs to the hubs.

Appendix A. Statistical Program Description

For analysis of the aggregate power emanating from a large area, the program written by FCC engineer Harry Ng was used with modifications to accommodate subscriber (CPE) transmissions. Modifications include the addition of subscriber antenna patterns, random subscriber-to-hub distance, power control, and a random azimuth for CPE transmission. The subscriber-to-hub distance is based on a maximum and minimum hub range. Subscriber antenna elevation angle is calculated from hub tower height and distance from the hub. Following is a description of the program calculations.

Inputs to the program are as follows.

- satellite altitude
- satellite half power beam width and antenna pattern
- satellite elevation angle at the edge of the half power beam width
- satellite earth station feeder link radiated power density
- CPE radiated power density at maximum range to the hub
- hub or CPE spacing within the footprint
- hub or CPE spacing outside the footprint
- hub tower height
- maximum CPE range to hub
- angle where CPE path blocking is expected

The program loops through latitude swaths equal to the CPE spacing. For each swath, the power as seen by the satellite antenna, is computed for each simultaneous CPE transmission. A matrix of latitude and longitude calculations is performed and the power is accumulated to obtain the aggregate power into the satellite. Each latitude swath is summarized in the output with the angle from the CPE to the satellite in 5 degree bins.

To accurately model the subscriber radiated power directed toward the satellite, the pointing angle of each subscriber antenna is randomly selected over 360 degrees with a uniform distribution. The azimuth and elevation angle of the subscriber antenna is used to calculate antenna pattern gain and the look-angle to the hub.

Look-angle to the hub is determined from the tower height and subscriber to hub distance. Based on the maximum range to the hub, the distance to the hub is randomly selected using square root of uniform distribution. The square root applies because subscriber density varies by area and the area varies by the square of the distance from the hub. Once the look-angle is calculated, the angle to the satellite is calculated from the satellite geometry and the subscriber antenna pattern is interpolated to find the radiated power density directed toward the satellite.

Subscriber power is based on the distance from the hub. Radiated power is reduced by the 20*log the ratio of the randomly selected distance to the hub and the maximum range.

Blocking is expected for low elevation angles of subscriber transmission such that line of sight to the satellite is blocked for 50% of the subscribers.

The aggregate power at the satellite is computed for locations in the half power beamwidth and outside the half power beam width. The total from both inside and outside the beamwidth is compared to the feeder power density to determine the C/I ratio.

The number of hubs in the footprint is geometrically computed from the SV antenna beamwidth, SV altitude and elevation angle to satellite and is provided as an output. The number of hubs outside the half power beamwidth is also an output.

Appendix B. Population/Subscriber Density Calculations

The number of simultaneously transmitting subscribers is based on the hub circuit capacity. To determine the number of subscribers (CPEs) transmitting simultaneously within the SV footprint, high density areas of the United States were used to calculate the number of hubs required. Footprint orientations of North-South along the Northeastern seaboard and East-West from the Northeast seaboard are summarized by state in the table below.

Table B.1 Population and Area for North-South and East-West Footprints

State	North-South	Population (millions)	Area x1000 (Sq Km)	East-West	Population (millions)	Area (K Sq Km)
NH	X	1.1	24.2			
VT	X	0.6	24.9			
MA	X	6.0	27.3	X	6.0	27.3
RI	X	1.0	4.0	X	1.0	4.0
CT	X	3.3	14.4	X	3.3	14.4
NY	X	18.2	139.8	X	18.2	139.8
NJ	X	7.8	22.6	X	7.8	22.6
PA	X	12.0	119.3	X	12.0	119.3
DC	X	0.6	.2			
DE	X	0.7	6.4			
MD	X	5.0	32.1			
VA	X	6.4	110.8			
WV	X	1.8	62.8			
SC	X	3.6	82.9			
GA	X	6.9	154			
OH				X	11.1	116.1
MI				X	9.5	250.7
IL				X	11.7	150.0
IN				X	5.7	94.3
WI				X	5.0	169.0
Totals		75	825.7		43	780.1

From the table above, the worst case footprint density would be North to South covering the Northeast and Mid-Atlantic coast. The area approximates a footprint of 400x2000 km^2 and contains a population of 75 million people. Using an average 3 people per household, the number of households would be 25 million.

Based on the upstream circuit capacity of the hub, the number of hubs required to serve the densely populated Northeastern area is described above. The number of subscribers transmitting is determined by the hub capacity. Worst case busy hour maximum loading is assumed such that all frequencies of all hubs are 100% active. The worksheet table below provides the calculation for average hub spacing for the satellite footprint. This table, for example, is for the TI system which uses the following system parameters.

a) Take rate factor = 0.25. This factor is a conservative estimate of the number of subscribers (CPEs) that would desire 2-way service.

b) Concentration = 4. This is the system circuit concentration (inverse of Erlang).

c) Frequency reuse = 4. The hub frequency is reused 4 times by providing 4 sectors with alternating polarization. In order to account for all CPE frequencies active at one time the spacing is based on 4 times the number of hubs.

d) Capacity of each hub is the worst case if the entire 150 MHz were loaded with RF channels.

e) Active CPE refers to the number of reused frequencies at the hub.

Table B.2 Calculation Worksheet for Determining Hub Spacing

1	B	C	D	E	F
2	ITEM INPUT	CALC	INPUT	RESULT	UNITS
3	Total Households		2.50E+07		Households
4	Take Rate Factor	D3*D4	0.25	6250000	Subscribers
5	Circuit concentration	E4/D5	4	1562500	Circuits required
6	Capacity of each Hub	D5/E6	5760	271	Hubs required
7	Frequency reuse factor	E6/D7	4	1085	CPEs
8	** For 400x2000 Sq. Km. footprint: **				
9	Area of population		800000		Sq. Km.
10	Average area per active CPE	D9/E7		737	Sq. Km./CPE
11	Average spacing (400x2000)	E10^0.5		27	Km.
12	** For original 200x1400 Sq. Km. footprint: **				
13	Original footprint area		280000		Sq. Km.
14	Average area per active CPE	D13/E7		258	Sq. Km./CPE
15	Average spacing (200x1400)	E14^0.5		16	Km.

Table note: The original spacing for 200x1400 footprint did not include ME, SC and GA due to the smaller footprint and was based on a CPE spacing of 17 Km.. The aggregate power calculations use 17 Km. spacing and was not changed to reflect the 27 Km. spacing now being predicted for the larger footprint.

Hub and CPE density outside the footprint is based on similar calculations for the continental US.

The number of CPEs transmitting on any frequency is equal to the hub capacity to receive the circuits. The hub density and average CPE spacing was calculated for the TI system for use in interference calculations. Other systems may be correlated to the results by applying a factor for the difference between system densities. For example, for the CellularVision system the average spacing for the large footprint (row 11, column E of Table B2) would be 43 km, resulting in an additional margin for the C/I ratio. This density also assumes worst case of 100% suitability for LMDS. In actuality, not all area or populous is suited for LMDS due to coverage, competition from other services or for economic reasons.

RULES FOR
LMDS SUBSCRIBER TRANSCEIVERS
IN THE
29.1-29.25 GHZ BAND

§101. Limitations on LMDS subscriber transceivers in the 29.1-29.25 GHz band:

a) shall not transmit an effective isotropically radiated power in excess of 20 dBW/MHz in clear air and shall reduce EIRP, as a minimum, for distances of less than the maximum distance from the hub in accordance with the following formula,

$$P(EIRP, dBW/MHz) = 20\ dBW/MHz + 20 \log d/D$$

where d = transceiver distance to the hub
D = maximum transceiver distance to the hub

b) shall not transmit an effective isotropically radiated power in excess of 14 dBW/MHz in clear air if power control in accordance with the formula in (a) is not used,

c) shall have an antenna pattern that shall meet the requirements of that shown in the antenna mask figure with the following characteristics:

and/ or as follows,

equivalent isotropically radiated power on antenna boresight as limited in (a) or (b) shall be reduced for angles of boresight in accordance with the following characteristics:

ATTACHMENT C

RULES FOR
LMDS SUBSCRIBER TRANSCEIVERS
IN THE
29.1-29.25 GHZ BAND

Degrees from Boresight	Relative Gain/EIRP in dB Azimuth	Elevation
0	0.00	0.00
1	0.00	0.00
2	-3.00	-3.00
3	-6.25	-6.25
4	-9.50	-9.50
5	-12.75	-12.75
6	-16.00	-16.00
14	-16.00	-16.00
15 $\leq$ 90	-30.00	-30.00

LMDS SUBSCRIBER TRANSCEIVERS
29.1-29.25 GHZ BAND

ANTENNA EIRP/MASK